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Introduction

Methods
Plantation Selection
Assessment Procedures
Data Analysis

Results and Discussion
Plantation Survey
Excess Natural Regeneration in Plantations
Natural Regeneration Stocking in the Eastern Region
Height and Leader Growth
Factors Affecting Survival and Growth
Site Vegetation

Summary

Literature Cited

Appendix I

Appendix II

Appendix III

Report FOR 2003-2

Assessment of 1989 to 1991 Plantations in Lowland Nova Scotia

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Natural Resources

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Assessment of 1989 to 1991 Container Plantations in Lowland Nova Scotia

Introduction

Reforestation by planting trees has increased dramatically in Nova Scotia since the implementation of Federal-Provincial Forestry Agreements in 1977. During 1989 to 1991, approximately 70,000,000 trees were planted in the lowland areas of Nova Scotia. Planting peaked in 1988 and remained high during 1989 to 1991 in which a total of 70,000,000 trees were planted in the lowland areas of Nova Scotia. An additional 7,000,000 trees, primarily Highland White Spruce[1], were planted by Stora Forest Industries in the highlands of Cape Breton, but were not included in this plantation survey.

Previous reforestation studies examining various aspects of plantation establishment included a plantation survey of private woodlots in the earlier years 1978-84 of the Federal-Provincial Agreements (L&F, 1988). That report dealt with a high percentage of red pine plantings and old field plantings which do not make up a large component of the more recent plantings. Seasonal planting trials in Nova Scotia in 1987 determined that softwood species could be successfully planted in Nova Scotia from spring through fall (L&F, 1989). Other factors such as frost heaving (L&F, 1992) and seasonal planting in the Cape Breton Highlands (L&F, 1988) have also been examined.

Various studies have discussed the occurrence of natural regeneration in plantations (Ackzell, 1994; Frank & Safford, 1970; Bernier, 1993). Proximity to adjacent seed bearing stands, good seed years, scarification and release from competition have been found to influence the occurrence and distribution of competing softwood natural regeneration (L&F, 1988; Ackzell, 1994). Harvest method has also been found to have a major effect on the survival of advanced growth and germination of new seedlings on clearcuts (McInnis and Roberts, 1990, Ruel, 1990).

This report will summarize the survey results of the container plantations established in 1989 to 1991 in terms of survival, stocking and early growth. Differences in plantation success are analysed by geographic region, species planted, site preparation, site history and tenure class. In addition, an attempt was made to determine the most common problems affecting early plantation establishment. A further aim is to describe the occurrence of natural regeneration in these plantations and to compare the competitive position of the naturals to planted trees. Regional differences in site vegetation and their effect on plantation establishment are also studied.

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[1] All species common and scientific names listed in Appendix III

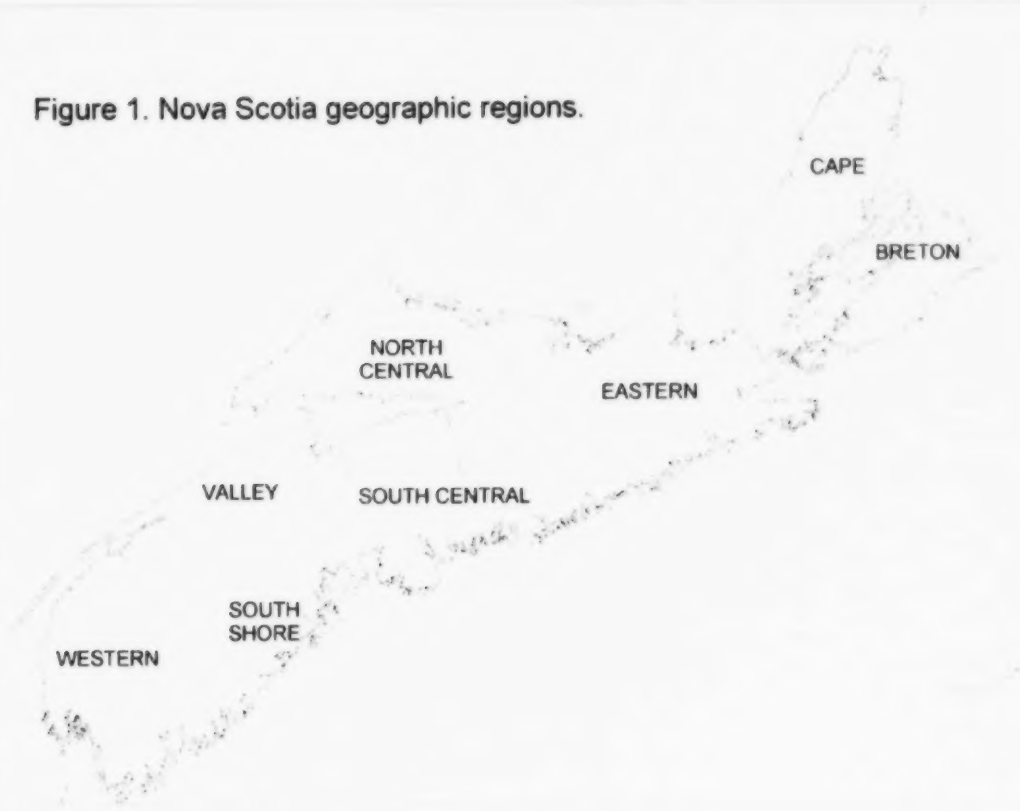
Methods

Plantation Selection

All areas planted in 1989 to 1991 with NSDNR grown container seedlings with the exception of the Cape Breton Highlands were included in this survey. Individual plantations were randomly selected according to the following criteria:

1. Proportional representation by total trees planted in each year 1989, 1990, 1991
2. Proportion of area planted by species for each geographic region shown in Figure 1
3. Area planted in each region by tenure class; small private, group venture, large landowner, leased crown and crown

Figure 1. Nova Scotia geographic regions.



Assessment Procedures

Selected plantations were assessed along pre-determined cruise lines to provide uniform coverage of the plantation. Circular 2.14 metre radius plots representing full stocking at 4 trees per plot were based on an average spacing of 1.8 x 1.8 metres. Plot sampling averaged 3.61 plots per hectare with a minimum of 10 and maximum of 50 plots per plantation. The number of plots established in each plantation was based on a sampling intensity of 0.5%.

Within plots, planted trees were tallied as healthy, unhealthy, dead or missing to determine survival. Missing trees were considered dead for survival and stock determination. Naturally regenerated softwoods were recorded as natural replacements if found in a quadrant of a dead or missing planted tree. Quadrants within plots that were considered non-plantable due to excessive slash, rock, water, etc. were recorded and deducted to determine plantable area. The second and fourth planted trees in each plot, if available, were measured for total height and leader length to the last complete growing season.

Plots with dead, missing or unhealthy planted trees were assessed for possible cause of mortality or reduced growth. Occurrences were noted as light, moderate or severe for each plot. A list of factors used for the survey is shown in Table 1.

Table 1.	Factors that may have affected the survival and growth of planted trees prior to survey date.
1	Competition
2	Browsing (rabbit and deer)
3	Frost Heaving
4	Insect and Disease Problems
5	Hylobius
6	Root Damage
7	Excessive Dryness
8	Wet Site
9	Frost Damage
10	Poor Microsite
11	Mechanical and Planting Damage
12	Herbicide Damage
13	Bare Mineral Soil (BMS)
14	Thick Duff
15	Loose Planting
16	Overwinter Damage
17	Unknown

Excess natural regeneration of softwoods, not included as natural replacements was recorded and measured in two ways during the survey.

1. In Central, Valley, South Shore and Western regions all softwood naturals were recorded as total excess trees per hectare by plantation. Tree heights were taken to determine mean total height by species by plantation.

2. In the Eastern and lowland Cape Breton regions, excess softwood natural regeneration were recorded by the stocked quadrant method. Total height and leader growth was measured by species within each plot.

As a result, regeneration densities and mean total height data existed for the total survey but stocking and current growth information could only be calculated for the Eastern and lowland Cape Breton regions.

An assessment of predominant competing vegetation species was made for each plantation as a whole and included up to six major species with percent cover and average height.

Stocking Equations

Stocking was calculated as 1) plantable area stocking for planted trees (PSP) and planted plus natural replacement trees (PSPN) and 2) total stocking for planted trees (TSP) and for planted plus natural replacement trees (TSPN) (Appendix I).

$$Plantable\ stocking\ of\ planted\ trees\ (PSP) = \left(\frac{Healthy + Unhealthy}{Numquads - NonPlants}\right) x100$$

$$Totalstocking\ of\ planted\ trees\ (TSP) = \left(\frac{Healthy + Unhealthy}{Numquads}\right) x100$$

$$Totalstocking\ of\ planted + naturalreplacement\ (TSPN) = \left(\frac{Healthy + Unhealthy + Natreplace}{NumQuads}\right) x100$$

$$Plantable\ stocking\ of\ planted + naturalreplacement\ (PSPN) = \left(\frac{Healthy + Unhealthy + Natreplace}{NumQuads - NonPlant}\right) x100$$

Results and Discussion

Plantation Survey

The plantation survey was conducted starting in the summer of 1992 and ended in the summer 1993. A total of 348 plantations were surveyed with one or more planted species per plantation. Approximately one third of the plantations surveyed occurred in each of years 1989, 1990 and 1991. Table 2 summarizes the plantations surveyed by geographic regions. The survey accounted for 9.6% of all trees planted by all agencies in the 1989 - 91 period. Average plantation size was 6.83 hectares as compared to 3.74 hectares in the 1985 survey (L&F, 1988). This increase resulted from larger plantations surveyed on large landowner, leased crown, and crown ownerships which were not included in the 1985 survey (Table 3).

Table 2. Summary of plantation survey information by geographic regions in Nova Scotia

Region	Number of plantations surveyed	Area (ha) surveyed	Total planted trees surveyed	Average plantation size	Average # of planted trees per plantation
Cape Breton	43	371	1,045,590	8.6	24,316
Eastern	79	752	2,020,170	9.5	25,572
North Central	97	565	1,694,185	5.9	17,648
South Central	38	213	602,815	5.7	16,292
Valley-South Shore	45	218	632,153	4.9	14,367
Western	46	259	723,295	5.7	16,073
Totals	348	2378	6,718,208	6.8	114,268

Plantations on small private lands (CAFD, Group Venture) accounted for 57% of area surveyed and averaged 4.9 hectares (Table 3). Plantations by Stora Forest Industries on leased crown accounted for 27 % of surveyed area and were the largest plantations surveyed averaging 27 hectares (Table 3).

Table 3. Summary of plantations surveyed according to tenure class				
Tenure Class	Number of Plantations surveyed	Areas surveyed (hectares)	Average plantation size (hectares)	% total area surveyed
Small Private (CAFD)	215	1,057	4.9	44
Large Landowner	10	77	7.7	4
Crown	29	278	9.6	12
Leased Crown (Stora)	24	647	27.0	27
Group Venture	70	319	4.6	13
Totals	348	2,378	6.8	100

Black spruce plantations accounted for 39% of the area surveyed, followed by white spruce 25%, Norway spruce 20%, red spruce 13%, eastern larch 1.5% and white pine 1%. Ninety-seven percent of all area surveyed was planted to spruce, contrasting a previous survey (L&F, 1988) in which 56% of areas were planted to spruce. In 1985, red pine was the most common species planted (36%) (L&F, 1988).

Seventy percent of plantations surveyed were established on softwood cutovers, 15% on mixedwood cuts, 7 % on hardwood cuts, 3.5% on old fields and 3% on old field white spruce cuts. Compared to the 1985 survey, old field plantings were reduced from 28% to 3.5% of the total area planted and softwood cutovers planted increased from 44 to 70% (L&F, 1988).

Between 1989-91, 59% of surveyed plantations were site prepared by brush rake and burning; followed by full tree logging 18%, brush rake only 12%, rolling and chopping 8%, no site preparation 5% and minor amounts by other methods.

Forty-five percent of plantation area surveyed had received one herbicide application as of the survey date.

Survival

The weighted mean survival (by area) for lowland Nova Scotia during 1989-1991 was 84.1%. Survival included both healthy and unhealthy trees of which 96% were considered healthy and only 4% unhealthy. There were no major differences in survival between establishment years, 87% in 1989, 84% in 1990 and 82% in 1991.

Percent survival by species was quite similar and varied between 83 and 87% (Figure 2). Very little difference in survival was noted among the planted spruce species in this survey (Figure 2).

Regional difference in plantation survival indicated an increasing trend from Eastern Nova Scotia (79.5%) to Western Region (92.5%) (Figure 2). Among tenure classes highest survival rates were recorded in the freehold crown plantations (90%) compared to 81% in leased crown areas (Figure 2).

Plantation survival increased from 72% in the 1985 survey to 84% in this survey (L&F, 1988). Possible explanations for this are, (1) improved planting practices, (2) consistent high quality container seedlings (multipot 67) or, (3) better survival with spruce compared to other planted species.

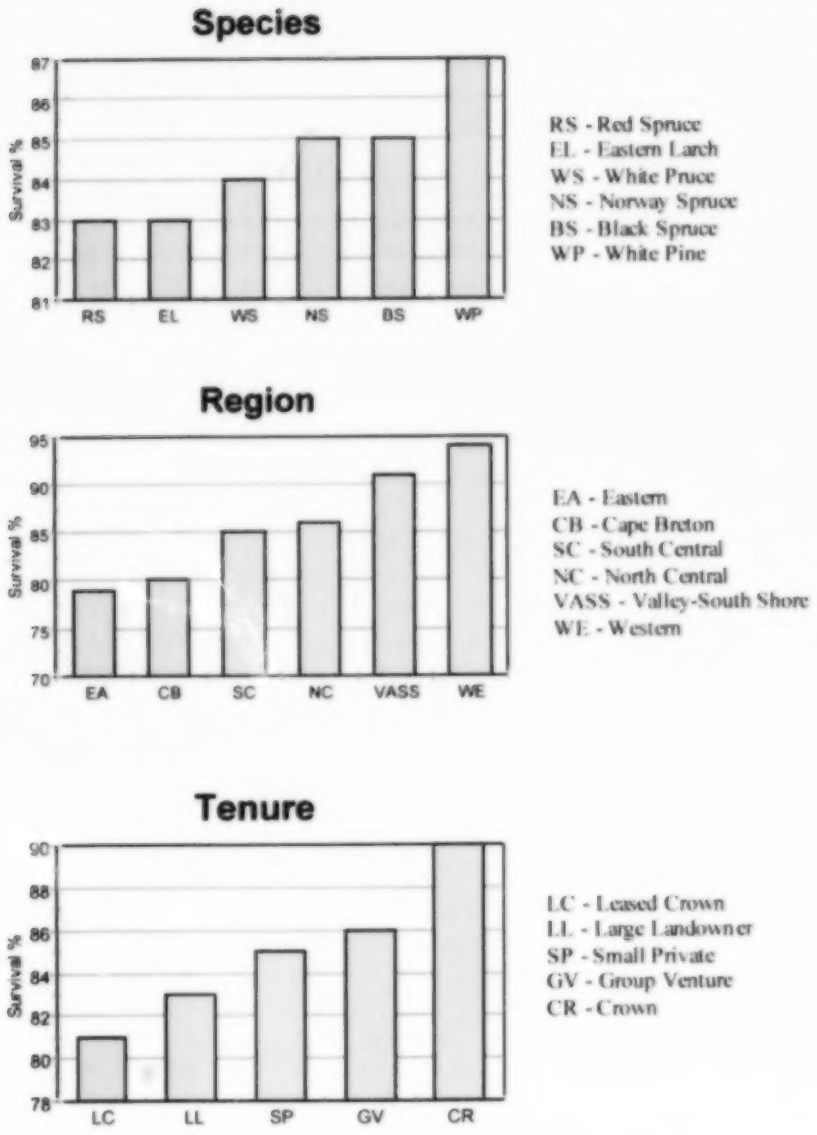
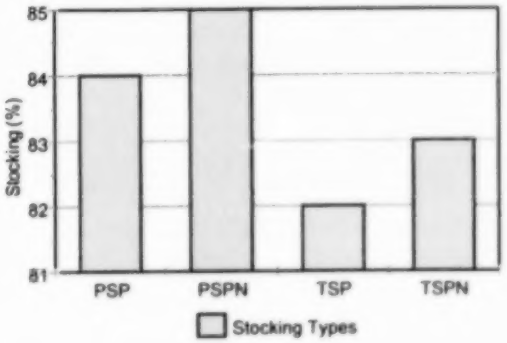


Figure 2. **Differences in survival % of 1989-91 plantations in lowland Nova Scotia by species, region and tenure class**

Stocking

Weighted mean stocking of planted plus natural regeneration replacements on plantable area (TSP) was 84.9% (Figure 3). Ninety-six percent of the planted area had stocking greater than 60% (Table 4). Total stocking exceeded 80 percent on 70% of the area surveyed (Table 4). Similar stocking results were recorded in a study in Newfoundland with planted black spruce and natural balsam fir (Earle, 1995).



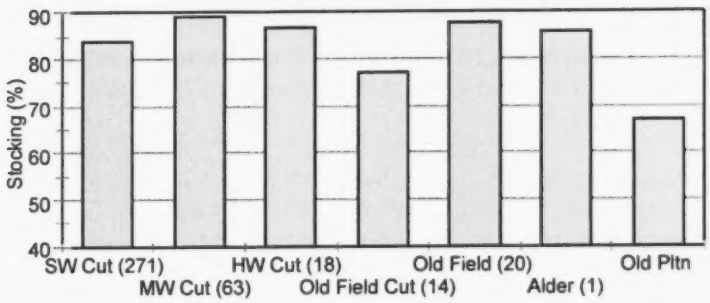
PSP - Plantable stocking to planted trees
PSPN - Plantable stocking of planted and natural trees
TSP - Total stocking to planted trees
TSPN - Total stocking of planted and natural trees

Figure 3. Stocking results from 1989-91 plantations in lowland* Nova Scotia
* excludes Cape Breton Highlands

Table 4.	Percent of Total plantation area based on stocking[1] class		
Stocking Class (%)	# of Plantations[2]	Area (ha)	% of Total Area
0 – 20	0	0	0
21 – 40	4	10.6	0.3
41 – 60	17	88.4	3.7
61 – 80	89	620.5	26.0
81 – 100	278	1658.5	70.0
Totals	388	2378.0	100.0

[1]PSPN – plantable stocking of planted and natural replacement trees
[2]Number of plantations based on single species areas only

Figure 4. Stocking of planted trees in relation to site history



There was no significant relationship found between planted stocking and plantation size, contrary to a previous study (L&F, 1985). Stocking of planted trees was not greatly affected by site history except in the old field white spruce cuts (Figure 4). Higher stocking was found in plantations that were more intensively site prepared (plow, disc, chop, rake and burn) compared to less intensive methods such as raking, full tree, herbicide and no site prep (Table 5).

Table 5. Mean planted stocking[1] to total area by site preparation method

Site Preparation	# of Plantations	Average (%) Stocking
C & H Plow	4	88
Rhom Disc	13	88
Roller Chopper	30	86
Brush Rake & Burn	231	84
Corridor Rake	5	83
Full Tree Logging	29	82
Brush Rake Only	43	80
No Site Prep	22	79
Herbicide	9	79
Hydro Ax	2	68

[1] TSP – Total stocking of planted trees

Natural Regeneration

Natural regeneration discussed in this section includes all commercial softwoods that were not tallied as natural replacement trees, but are considered excess trees within the plots. Natural regeneration of softwoods in surveyed plantations ranged from a hig of 37,950 stems/ha to a low of 0 stems/ha which occurred in 24 plantations. Thirty-one percent of areas surveyed averaged greater than 3,000 trees per hectare but most were between 3 - 10,000 trees per hectare (Figure 5).

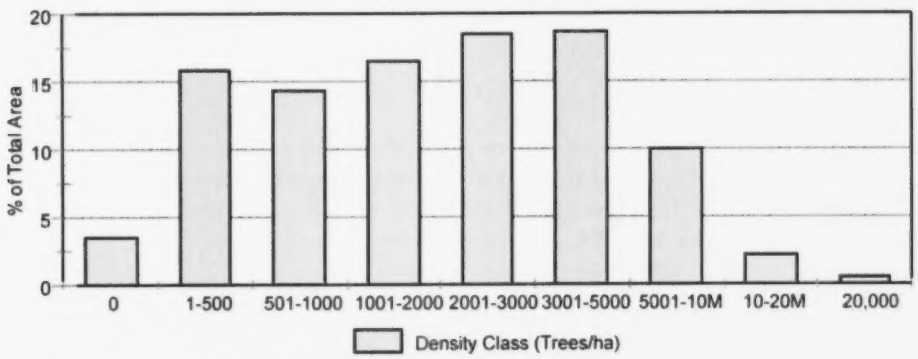


Figure 5. Distribution excess of softwood regeneration by mean density class

Excess softwood regeneration was most abundant in Cape Breton averaging 3955 trees per hectare with 51% of planted area containing greater than 3000 trees per hectare. Density of softwood regeneration declined consistently from Cape Breton to western Nova Scotia (Table 6). In the western regions 50% of planted area regenerated less than 1000 excess softwood trees per hectare (Table 6).

Table 6. Excess softwood natural regeneration in surveyed plantations by region					
Region	Mean SW Regen (trees/ha)	Percent of Total Area			
		3000+ /ha	2-3000 /ha	1-2000 /ha	0-1000 /ha
Cape Breton	3955	51	23	9	17
Eastern	3628	45	15	9	31
North Central	2575	19	25	21	35
South Central	1891	27	13	30	30
Valley/South Shore	1866	15	17	20	48
Western	1627	6	15	24	55

Species composition of naturally regenerated softwoods was limited to balsam fir, spruce species which included red, white and black but were not differentiated, Eastern larch , Eastern white pine and Eastern hemlock. Ninety-one percent of excess softwood regeneration consisted of spruce (46%) and balsam fir (45%) (Table 7). Eastern larch accounted for 7.5% and white pine and hemlock were very minor components of recorded naturals (Table 7). Spruce was found in 86% of plantations and averaged 1521 trees per hectare compared to balsam fir, at 82% of plantations and a mean density of 1368 trees per hectare. Spruce and balsam fir were both major components of regeneration in all regions (Table 8), but North Central and Western Regions recorded a higher density of spruce regeneration compared to balsam fir (Table 8). Balsam fir (2080/ha) regenerated in higher amounts in the Eastern region (Pictou, Antigonish and Guysborough) than spruce (1922/ha) but the difference was minimal (Table 8).

Table 7. Excess of natural regeneration in 1989-91 plantations by species				
Species	% Occurrence[1]	Total Trees Recorded	% of Total Natural Regeneration	Average Density[2] (trees/ha)
Spruce	86	12327	46.0	1521
Balsam Fir	82	12100	45.0	1368
Eastern Larch	32	2031	7.5	825
White Pine	14	213	0.8	157
Hemlock	4	147	0.6	665
Jack Pine	0.5	15	0.1	253

[1] Occurrence of regeneration as a percent of total plantations surveyed
[2] Density of species in represented plantations

Table 8. Mean density of naturally regenerated species by geographic region of Nova Scotia

Geographic Region	Mean Density[1] (trees/ha)				
	Spruce	Balsam Fir	Eastern Larch	White Pine	Hemlock
Cape Breton	1914	1855	2317	200	-
Eastern	1922	2080	445	91	1698
North Central	1767	1121	461	68	256
South Central	839	798	957	317	160
Valley-South Shore	1037	1003	205	130	35
Western	1120	740	414	205	112

[1] Density based on plantations of occurrence

Influences on excess natural regeneration in plantations were analysed for the following factors: 1) forest covertype, 2) site preparation, 3) plantation size, 4) year of planting, 5) herbicide activity, 6) drainage, 7) soil type and 8) topography. The strongest trends were found with forest covertype, site preparation, year of planting, drainage and soil type. Softwood and mixed-wood harvest areas regenerated significantly higher densities of softwood regeneration (3025 stems/ha) compared to hardwood and old field plantations (700 stems/ha). This is consistent with a previous Nova Scotia study (L&F, 1988).

Low physical impact scarification methods except for brushraked and burning had higher mean densities compared to plowing, discing and roller chopping (Figure 6). Highest densities were found on full-tree logged sites (3950/ha) which were located in the Eastern Region. Ackzell (1994) and other authors have found that scarification promotes establishment of certain softwoods, but the intensive methods (plowing, discing, rolling, etc.) also destroy advanced or existing regeneration, to a greater extent than full-tree or herbicide methods.

Regeneration density was affected both by site drainage and soil type based on this survey. Sites with moderate to imperfect drainage averaged 3780 stems/ha compared to both wet or dry sites at 1630 stems/ha (Figure 6). Results from this survey also produced a trend of increased softwood regeneration in fine textured loam and clay soils than coarser soil types (Figure 6). Ackzell (1994), however, did not find any correlation between regeneration density and soil type in Sweden.

Softwood regeneration density was highest in 1989 plantations (3600 stems/ha) compared to 1990 (2800 /ha) and 1991 (1700/ha). This trend could have been influenced by the occurrence of a large seed year in Nova Scotia during 1988[2]. Frank & Safford (1970) found that seeds existing in the forest floor most likely germinate the first year following seedfall, but in the surveyed plantations the actual date of harvest was not recorded.

Post planting herbicide (3500/ha) applications had a higher mean density of softwood regeneration than no herbicided sites (2500/ha), but results are highly variable across the province.

Natural Regeneration Stocking in the Eastern Region

In the Eastern Region excess natural softwood regeneration was recorded by stocked quadrants as well as density. Survey results indicated that 9.3% of planted areas were stocked to natural regeneration (60+%) according to Nova Scotia stocking standards and thus would not have required planting (Table 9). The question remains whether these areas were stocked at time of planting or ingrowth occurred following the planting date.

[2]Brian White, personal communication

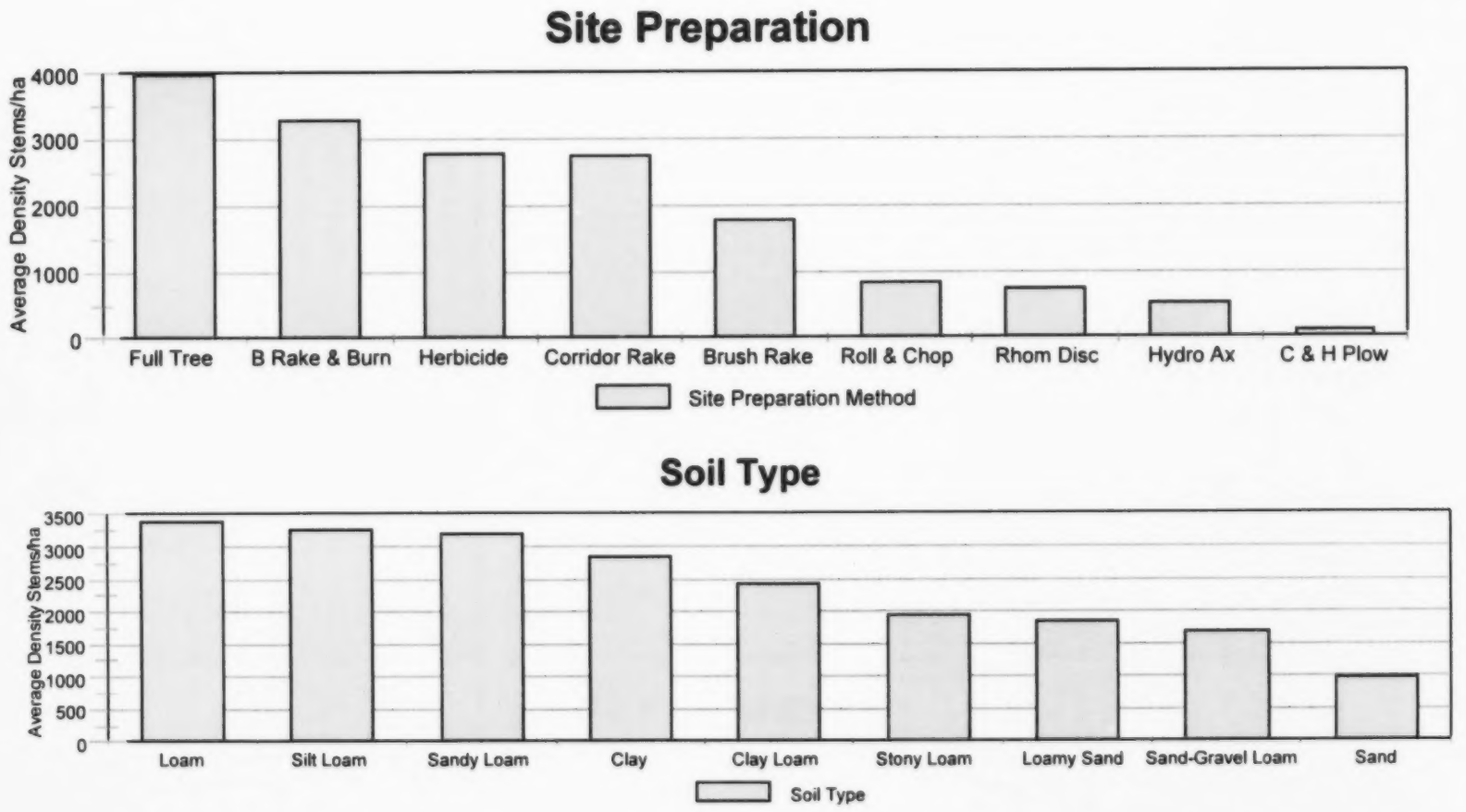
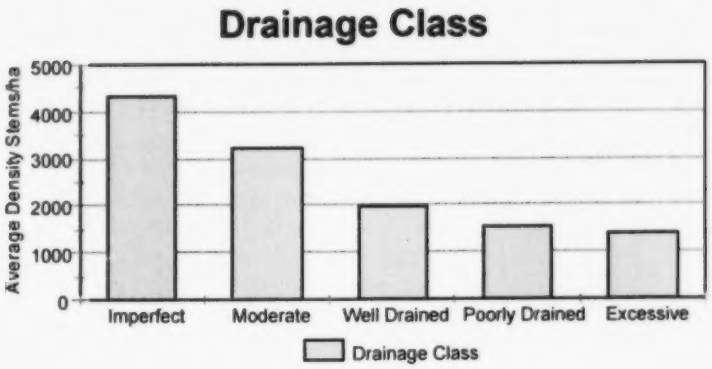
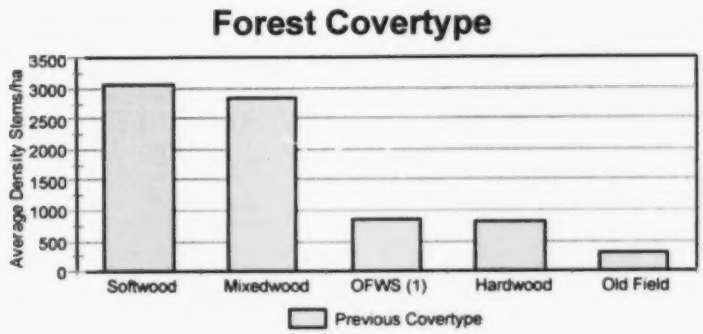


Figure 6. **Density of excess natural regeneration in plantations influenced by site preparation, soil type, drainage class, forest covertype and year of planting.**





(1) Old Field White Spruce Harvest Sites

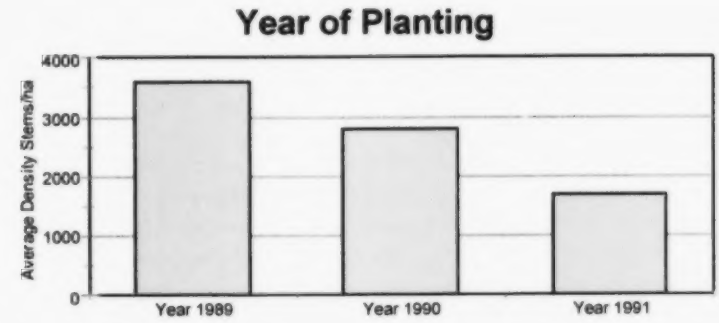


Figure 6 con't. **Density of excess softwood natural regeneration in plantations influenced by site preparation method, soil type and drainage class, forest covertype and year of planting**

Table 9.	Summary of stocking and density of softwood natural regeneration in Eastern and Cape Breton regions				
Stocking Class (%)	# of Plantations	Plantation Area (ha)	% of Total Area	Average Density trees/ha	Density Range trees/ha
60+	20	104.3	9.3	12427	3761 - 32387
40 - 59	16	268.4	23.9	5023	1529 - 13071
20 - 39	39	481.9	42.9	2775	695 - 15368
0 - 19	47	268.8	23.9	424	0 - 2363
Totals	122	1123.4	100		

Sixty-seven percent of the surveyed plantations were between 20 and 60 percent stocking to natural softwoods and 24% of areas had less than 20% stocking of excess softwood natural regeneration. Based on results in the Eastern region, 33% of plantations contain at least 7200 planted and natural trees per hectare, while an additional 43% contain approximately 5000 commercial softwood per hectare (Figure 7). Based on these results, 76% of plantations in the Eastern region may require a density control treatment in the future.

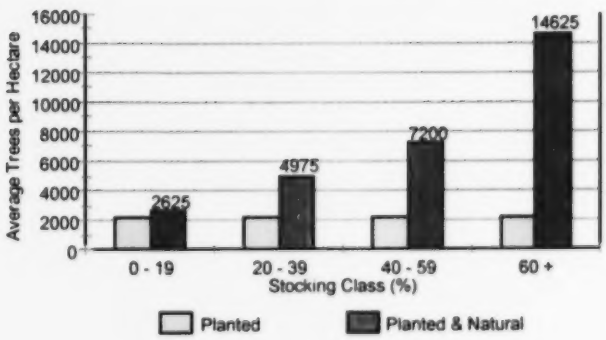
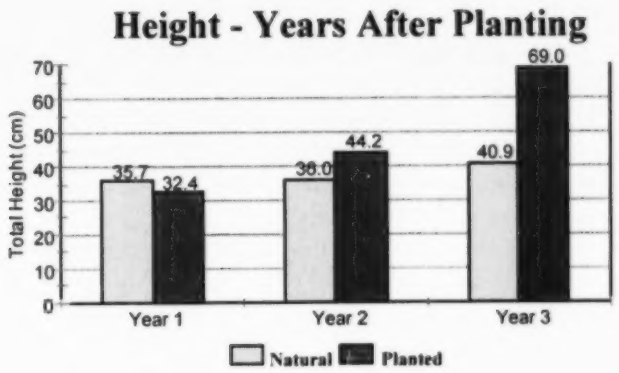


Figure 7. Total mean density of planted and naturally regenerated softwoods by stocking class in the Eastern Region

Height and Leader Growth

Height growth measurements were taken, (1) to indicate mean growth rates of planted trees in the early establishment phase, (2) to show differences between early growth rates of different species and, (3) to compare early growth rates of planted and natural trees.

Margolis & Brand (1990) found that absolute growth rate measures were difficult to use as growth indicators because of the influence of current and initial size, but because of the large numbers of sampled trees and the consistency of stock type, initial size is less of a factor for growth comparisons. Province wide results show that three years after planting the mean height for all species was 69 cm and trees were growing at a faster rate each year (Figure 8). There did not appear to be a growth lag or period of adjustment which was occurred in the 1985 study (L&F, 1988). Mean leader growth rates for container spruce were 21.0 cm three years following planting compared to 12.1 cm five years after planting in the 1985 survey (L&F, 1988).



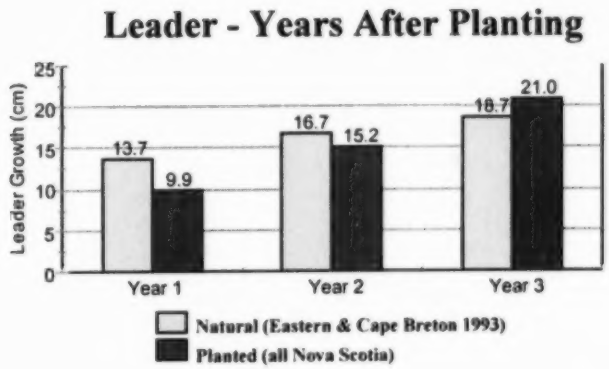


Figure 8. **Comparison of mean height and leader growth of planted and naturally regenerated trees in early years after planting**

Differences in early leader growth following planting were quite evident between spruce, pine and eastern larch (Figure 9). Mean growth rates for eastern larch increased from 20 cm to 47 cm by year three compared to 11 cm to 21 cm for black spruce in the same time period. Black spruce, Norway spruce and white spruce all experienced steady early growth rates, but red spruce took two years to acclimatize and then increased leader growth considerably in the third year (Figure 9).

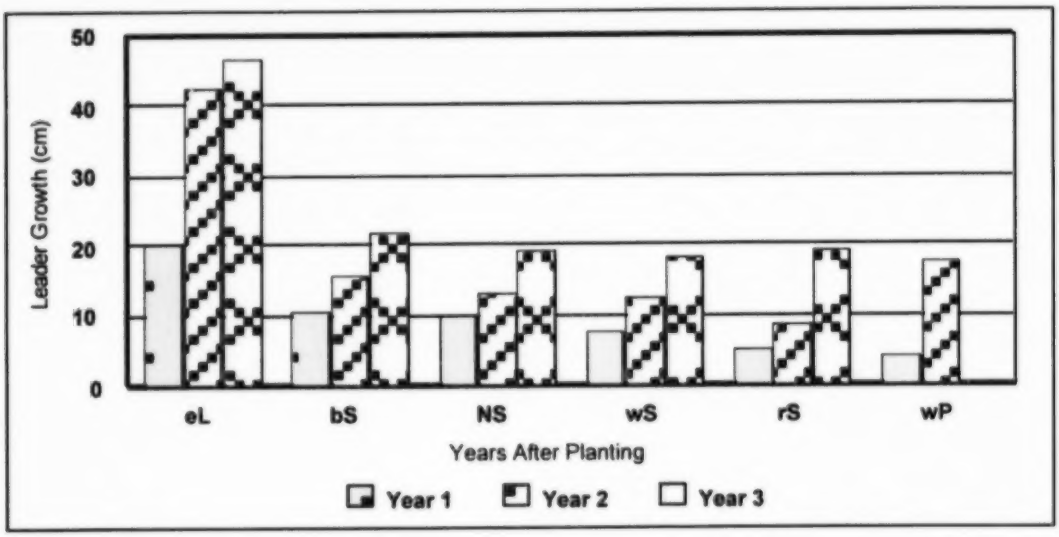


Figure 9. Comparison of mean leader growth of species planted in Nova Scotia, 1989 - 91

Comparisons of total height between planted and natural trees are difficult because of a lack of age data for natural trees, but Figure 8 shows the relative height difference at the time of survey. Differences were small in the 1990 and 1991 plantations, but planted trees were 30 cm taller in plantations established in 1989 (Figure 8). Growth results from the Eastern Region indicate that naturally regenerated species are actually growing faster than planted trees established in the first and second year after planting (Figure 8), however, 1989 planted trees (21.0 cm) have surpassed the growth rates of naturals (18.7 cm) in the third growing season (Figure 8). Table 10 shows that each planted species is growing faster than the same natural species established in 1989 plantations. Bernier (1993) found that with black spruce seedlings, natural trees of same height as planted trees at time of planting grew faster for at least two seasons while planted trees became acclimatized to the planting site. Results from this survey indicate that even with slower growth rates of naturals, plantations with high densities may

require pre-commercial thinning (PCT) to maximize the growth of crop trees, either planted or natural.

Table 10. Comparison of 1993 leader growth of natural regeneration species and trees planted in 1989

Species	Leader growth (cm) 1993 growing season	
	Natural Regeneration	Planted Trees
Spruce (rs, bs, ws)	13.3	20.1
Balsam Fir	14.7	-
Eastern larch	31.9	46.8
White Pine	10.4	17.8[1]

[1] Leader growth of 2 year old planted white pine (1990)

Factors Affecting Survival and Growth

An assessment in each plantation (by plot) was made by the survey team to determine (if possible) the causes of seedling mortality or reduced growth. A total of 17 different possible causes were considered throughout this survey and expressed in terms of occurrence by plot (Appendix I). Factors listed by occurrence provides reforestation practitioners with a general list of problems that are considered detrimental to the establishment of planted trees. Some factors may be prevented by proper planter instruction (microsite, frost heaving, improper planting, thick duff and wet site), or careful management (competition, Hylobious, herbicide, etc.), while others are climatic problems that are difficult (if not impossible) to control.

Browsing (deer or rabbit) was the most common problem recorded, with 36.5% of surveyed plantations experiencing some damage (Table 11). Thirty-two percent of surveyed plantations had no observed problems affecting the trees and 5% of plantations had problems which were not identified . In addition to browsing, the most common factors that affected the success of the planted trees were (1) competition, (2) microsite, (3) wet site and (4) frost heaving (Table 11).

Twenty-four of surveyed plantations (7%) had more than 40% of plots affected by problems (Table 11). Browsing accounted for 50% of the problems recorded in the most severely affected plantations, followed by wet site with 15 percent. Individual plantations found with notable problems were, (1) an Eastern larch plantation killed by herbicide, (2) two red spruce plantations severely damaged, one by winter kill and one with high incidence of hylobious damage.

Table 11.	Summary of occurrences of factors that affected survival and early growth of 1989-91 plantations in lowland Nova Scotia					
Factors	# of Plantations Affected	% of Total Plantations	# of Plantations		Total Occurrences # of Plots Affected	% of Total Occurrence
			with > 40% of Plots Affected	with >10% of Plots Affected		
Browsing	127	36.5	12	29	399	30.7
None	114	32.7	-	-	-	-
Competition	57	16.4	2	5	122	9.4
Poor Microsite	56	16.1	1	6	120	9.2
Frost Heaving	46	13.2	0	3	89	6.8
Wet Site	43	12.3	4	8	145	11.1
Dryness	34	9.8	1	2	68	5.2
Over Winter Damage	20	5.7	1	4	100	7.7
Thick Duff	20	5.7	0	3	57	4.4
Unknown	18	5.3	0	1	37	2.8
Frost	16	4.6	0	0	22	1.2
Hylobious Beetle	15	4.3	1	4	42	3.2
Bare Mineral Soil	13	3.7	0	0	19	1.2
Animal Damage	13	3.7	0	0	17	1.3
Mechanical & Planting	12	3.4	0	1	21	1.6
Insect & Disease	8	2.2	0	1	14	1.1
Root Damage	6	1.7	0	0	10	0.8
Loose Planting	5	1.4	0	0	8	0.6
Herbicide	1	-	1	1	10	0.7
Total			23	68	1300	100

Norway spruce and red spruce had the highest occurrences of problems among planted species. Norway spruce was the most severely affected species by browsing accounting for 10 of 12 plantations that had more than 40 percent of plots affected (Table 11). Planting of Norway spruce in wet sites resulted in higher occurrence of stunted and chlorotic trees than other planted species.

Red spruce was most severely affected by Hylobious beetle, winter damage and to some extent browsing. All plantations in the survey with greater than 10% of plots damaged by either Hylobious beetle or overwinter damage were red spruce.

Site Vegetation

Vegetation cover for each plantation was described by percent cover and mean height for the major species identified. A competition index based on the following formula was developed:

$$Competition\ Index = \frac{Total\%\ Cover\ of\ Vegetation\ Species\ x\ Mean\ Height\ of\ Vegetation}{Mean\ Height\ of\ Planted\ Species}$$

Linear regression analysis produced very little association between the competition index and percent survival or stocking, although incidences of severe competition were found to negatively affect survival in this survey. Competition has been reported to affect seedling mortality and early growth in several studies (Oxenham, 1983, MacDonald *et al*, 1990) but in this survey where individual trees were not assessed for competition and many plantations had already been herbicided for competition control, direct relationships were difficult to determine.

Occurrence of the major vegetation species found in plantations in lowland Nova Scotia is summarized in Table 12 and compared to results from the 1985 survey (L&F, 1988). Overall occurrences are higher in the 1992-93 survey but many of the same species are represented. Grass and raspberry results are similar, but occurrences of red maple, white birch and aspen are considerably higher in the 1992-93 survey, while alder and herbaceous are more common in the earlier plantations. These differences could be attributed to the shift in original site history from a higher number of old field and alder sites in earlier plantations to a high percent of softwood and mixedwood cutovers in the 89-91 plantations. Regional differences in vegetation occurrence are summarized in Appendix II.

Table 12. Comparison of the 10 major vegetation species found in plantations from the 1985 and 1992-93 surveys			
1992 – 93 Survey		1985 Survey	
Species	% Occurrence	Species	% Occurrence
Grass spp	75	Grass spp	51
Rubus spp	57	Rubus spp	45
Red Maple	50	Herbaceous spp	31
White Birch	32	Alder	17
Kalmia	18	Red Maple	15
Aspen	16	Ericaceous spp	11
Herbaceous spp	15	Pin Cherry	8
Pin Cherry	14	White Birch	7
Sphagnum spp	13	Willows	4
Alder	13	Aspen	3

Summary

A summary of results from the 1992-93 plantation survey are as follows:

1. Mean stocking of planted and natural replacement trees was 85%.

2. Survival of planted trees averaged 84%, with very little difference among species.

3. Survival increased consistently from a low of 79% in the Eastern Region to a high of 92% in Western Nova Scotia.

4. 96% of plantations surveyed had stocking greater than 60%, seventy percent were greater than 80% stocked.

5. Natural regeneration to softwoods exceeded 3000 stems per hectare on 31.4% of surveyed plantations.

6. Natural regeneration was highest in Cape Breton (3955 stems/ha) and declined to a low of 1627 stems/ha in the Western region.

7. 91% of natural regeneration was spruce (46%) and balsam fir (45%) across the province. Spruce occurred in 86% of plantations of a mean density of 152!/ha compared to balsam fir in 82% of plantations averaging 1368 per hectare.

8. Strongest factors that affected density of natural regeneration were site history, site preparation, drainage class and year of planting.

9. Natural stocking results in the Eastern and Cape Breton Regions indicated 9% of plantations were stocked to naturals (60+%), 67% were between 20 - 60 percent and 24% below were below 20 percent stocking.

10. 76% of surveyed plantations in the Eastern and Cape Breton Regions may require a PCT treatment to maximize growth rates.

11. Eastern larch growth rates during the first three years were over 100% greater than spruce and white pine. Red spruce experienced slower acclimatization to site and slower early growth than other species.

12. Mean total height of natural and planted trees were similar in 1990-91 plantations, but planted trees were 30 cm taller in 1989 plantations.

13. 1992-93 leader growth of naturals exceeded that of planted trees in 1990-91 plantations, but the reverse was true in the older 1989 plantations.

14. Browsing was the most common problem affecting planted trees, particularly Norway spruce with 36.5% of plantations experiencing some damage. Norway spruce accounted for 83% of plantations with greater than 40% of plots affected by browsing.

15. Plantation sites were predominantly softwood cutovers, compared to a high percent of old fields and older sites in earlier years, thus contributing to higher numbers of natural softwoods and intolerant hardwoods compared to the 1985 survey.

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Appendix I

Explanation of terms used as factors affecting survival and growth	
Factor	Description
Browsing	Damage caused by rabbits or deer.
Competition	Severe competition overtopping planted trees resulting in mortality or restricting growth.
Poor Microsite	Poor site selection during planting process except extreme wetness
Frost Heaving	Planted trees uprooted from soil by frost.
Wet Site	Trees planted in depressions which remain under water part of the year.
Excessive Dryness	Trees affected by extreme dryness due to excessive drainage and/or prolonged drought.
Over Winter Damage	Trees damaged by extreme cold, wind burn or snow damage.
Thick Duff	Trees planted with roots in duff causing mortality or desiccation due to dryness.
Frost Damage	Growth loss to foliage caused by late or early subzero temperatures.
Hylobious	Girdling damage caused by Hylobious beetle.
Bare Mineral Soil	Trees planted in exposed mineral soil and have suffered mortality or reduce growth.
Animal Damage	Miscellaneous damage to trees caused by animals other than browsing.
Mechanical and Planting Damage	Damage caused by equipment, and/or improper planting or handling.
Insect and Disease	Mortality or loss of growth caused by insect feeding or fungal diseases.
Root Damage	Miscellaneous root damage other than extreme wetness or frost heaving.
Loose Planting	Damage or mortality caused loosely planted trees.
Herbicide	Mortality or damage caused by herbicide applicaton.

Appendix II

Mean percent cover of major vegetation species in plantations by region of Nova Scotia.						
Species	Mean Percent Cover in Plantation					
	Cape Breton	Eastern	North Central	South Central	Valley & South Shore	Western
Grass spp	43	36	36	51	35	26
Rubus spp	17	15	14	6	21	27
Ericaceous spp	-	-	-	-	-	17
Herbaceous spp	-	-	4	-	-	-
Bracken Fern	6	-	4	-	-	-
Kalmia	4	3	3	8	11	7
Red Maple	8	7	4	9	25	13
White Birch	6	3	6	11	17	7
Aspen	-	3	2	3	6	2
Alder	-	2	-	5	7	4
Pin Cherry	3	3	3	4	-	-
Blueberry	-	-	3	4	-	-
Sphagnum spp	-	4	5	7	-	-
Fern spp	2	3	-	-	9	6
Moss spp	5	3	-	-	-	-
Grey Birch	-	3	-	-	-	-

Appendix III

List of species common and scientific names	
Common Name	Scientific Name
White spruce	*Picea glauca (Moench) Voss*
Red pine	*Pinus resinosa Ait.*
Black spruce	*Picea mariana (Mill.) B.S.P.*
Norway spruce	*Picea abies (L.) Karst.*
Red spruce	*Picea rubens Sarg.*
Eastern larch	*Larix laricina (DuRoi) K. Koch*
White pine	*Pinus strobus L.*
Balsam fir	*Abies balsamea (L.) Mill.*
Eastern hemlock	*Tsuga canadensis (L.) Carr.*
Jack pine	*Pinus banksiana Lamb.*
Hylobious beetle	*Hylobious congener*
Raspberry species	*Rubus spp.*
Red maple	*Acer rubrum L.*
White birch	*Betula papyrifera Marsh*
Aspen	*Populus spp.*
Alder	*Alnus spp.*
Pin cherry	*Prunus pensylvanica L.f.*
Sphagnum moss	*Sphagnum spp.*
Willow	*Salix spp.*
Bracken fern	*Pteridium aguilinum (L.) Kuhn.*
Blueberry	*Vaccinium spp.*
Grey birch	*Betula populifolia Marsh.*
Kalmia	*Kalmia spp.*

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